The European Zoological Journal, 2017, 96–103
Vol. 84, No. 1, http://dx.doi.org/10.1080/11250003.2017.1281355

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The protected taxon *Ocypode cursor* (Linnaeus, 1758) (Crustacea: Decapoda: Ocypodidae) – documenting its well-established presence in the central Mediterranean

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(Received 14 November 2016; accepted 26 December 2016)

Abstract
Ocypode cursor (Linnaeus, 1758) is the only *Ocypode* species present in the Mediterranean Sea, and one of the nine marine crustacean species protected in the basin. It is widely distributed in the eastern Mediterranean, but knowledge about its presence in the central Mediterranean is very limited so far. We hereby first document the established presence of *O. cursor* in the central Mediterranean (Sicily and Malta), backdate the known presence of this taxon in Italy, and offer preliminary observations on the main known Maltese population. In Sicily, *O. cursor* is distributed along most of the south-western coast of the island of Sicily, whilst at least three beaches in the Maltese Islands are known to support populations of this species. The main Maltese population exhibits numerous similarities (e.g. burrow width, zonation along the beach) to another Mediterranean population studied in northern Cyprus, although occurring at lower densities. We conclude that the species has been probably present within the study area for a long period, but went undetected in view of the low population densities at which it previously occurred, the lack of a comprehensive census for the species within the same study area, and its nocturnal habits. The presence of this species in the central Mediterranean seems to be attributable to secondary natural spreading.

Keywords: *Brachyura, population, intertidal, beach, dispersal*

Introduction

Species belonging to the genus *Ocypode* Weber, 1795 are large-sized semi-terrestrial crabs widely distributed in tropical and sub-tropical regions throughout the world, where they dig deep burrows from the low intertidal zone of open sandy shores (Sakai & Türkay 2013; Lucrezi 2015). Commonly known as ghost crabs due to their nocturnality and their generally pale colouration that blends in well with the sand (Karleskint et al. 2009), they are predators of small animals, including early juveniles of turtles, and generalist scavengers, whose cleaning activity makes them important components of sandy beach food webs (Trott 1999; Valero-Pacheco et al. 2007; Türeli et al. 2009; Lucrezi & Schlacher 2014; Marco et al. 2015). Being negatively affected by human activities, they also constitute valuable ecological indicators for quickly assessing the impact of disturbance on beach habitats (Branco et al. 2010; Schlacher et al. 2011; Noriega et al. 2012; Jonah et al. 2015; Lucrezi 2015).

More than 20 species are so far recognised as valid in *Ocypode*, of which only the tufted ghost crab *Ocypode cursor* (Linnaeus, 1758) is present in the Mediterranean (Davie & Türkay 2009; Sakai & Türkay 2013). Due to its wide and versatile ecological value, as well as its peculiar and limited habitat, *O. cursor* is one of the nine marine crustacean species protected in the Mediterranean, and the only one among them that is not subjected to fishing disturbance. It is, in fact, listed among the

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Endangered or Threatened Species (Annex II) of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention 1995), and among the Strictly Protected Fauna Species (Annex II) of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1996–98).

This taxon, easily distinguished from its congeneric taxa by the presence a tuft of bristles at the end of its eyestalks, shows a disjointed distribution, occurring in the Atlantic, along the west coast of Africa from southern Mauritania to northern Namibia and Cabo Verde Archipelago (Sakai & Türkay 2013; Lucrezi & Schlacher 2014; Rodrigues et al. 2016), and in the eastern and central Mediterranean (Ziese 1985; Glaubrecht 1992; Stevcic & Galil 1994; Strachan et al. 1999; Kocatas et al. 2004). However, whilst its presence from Egypt across the Levant to Turkey and southern Greece has been widely published in the past (see above), knowledge about its presence in the central Mediterranean is very limited so far. For instance, along the northern part of the Strait of Sicily, *O. cursor* was recorded from three small areas, namely Lampedusa – Pelagian Islands (Italy) (Froglia 1995; 2008 [2010]), Sampieri – Ragusa (Sicily, Italy) (Relini 2009) and Avola (Sicily, Italy) (Tiralongo in Mytilineou et al. 2016). From the Pelagian Islands, the species is only known from two male specimens (Length of carapace (LC): 12.2 and 17.1 mm) collected on 15 July 1987 by R. Argano from the Isola dei Conigli beach (Lampedusa) and currently preserved at Istituto di Scienze Marine (CNR – Ancona) (C. Froglia, personal communication), whilst the species is known from Sampieri and from Avola only through a few photographs.

Assessment of population parameters, including updated distributions and local individual densities, and of general morphometric features constitutes a valid tool for understanding the degree of pressures a species faces and, thus, devising long-term conservation strategies (Wisdom et al. 2000). In this context, we hereby report for the first time the established presence of *O. cursor* in the central Mediterranean (southern Italy and Malta) and present preliminary observations on the main Maltese population.

Materials and methods

Malta

The occurrence of *Ocypode cursor* in the Maltese Islands was first noticed by one of us (AD), based on photos posted on social media in June 2016. In order to determine the current distribution of *O. cursor* on the Maltese Islands, systematic searches for the occurrence of this species were done on all the sandy and shingle beaches of the island of Gozo between 11 pm and 3 am in June–July 2016. Once sites of presence were detected, these were subsequently revisited with the aim of taking morphometric measurements on caught individuals directly in the field, and to make observations about the general behaviour, activity patterns, zonation and burrowing dynamics of the ghost crab populations in question. Individuals were sampled by direct chasing and manual collection, rather than with traps, with an attempt being made to capture any individual encountered during the beach surveys. Morphometric measurements here taken were the length of the carapace (LC), the width of the carapace (WC) and the total span (TS), which is the distance between the tip of the longest right appendage and the tip of the longest left appendage. Very recently, the same author was also informed about a further site of presence in the island of Malta, which was subsequently confirmed by direct samplings.

Italy

Unpublished data of *O. cursor* from the southern coast of Sicily was mostly obtained from citizen scientists, who since 2007 have communicated sightings to two of us (BZ and GI), but also through occasional, ad hoc visits to beaches conducted along the eastern and south-western coasts of the island of Sicily over the same period. Given the geographical extent of the distribution of the species in Sicily, no morphometric or observational data was collected on these tufted ghost crab populations.

Results

Ocypode cursor populations here recorded from the central Mediterranean Sea are reported in Table I and mapped in Figure 1.

The species was encountered in June–July 2016 in the island of Gozo only at Ramla l-Hamra (Figure 2 (A–D)) and San Blas, two north-facing beaches at an approximate distance of 2 km from each other, and in September in Mgiebah, along the north-eastern coast of the island of Malta. Several faunal observations were carried out on the Ramla l-Hamra population: (i) a total of 108 and 173 burrows were counted during two visits to the beach; (ii) very high densities of ghost crab burrows were recorded along the western swathes of the beach, although some burrows seemed abandoned (Figure 2(C)). The majority of the adult burrows were recorded in the close vicinity of the mouth of the watercourse reaching the adlittoral, whilst the majority of juvenile burrows were zoned

Table I. Localities where *Ocypode cursor* (Linnaeus, 1758) populations were found (see also Figure 1), with coordinates, dates, and notes.

No.	Site	Geographical coordinates		Dates	Notes
		Latitude (°N)	Longitude (°E)		
B1	Ramla l-Hamra	36.061574	14.284018	June–July 2016	Faunal observations available
B2	San Blas	36.056770	14.300653	June–July 2016	Faunal observations available
B3	Mgiebah	35.967714	14.382100	September 2016	Faunal observations available
C1	Funcitella-Siculiana	37.355074	13.356823	June 2014	Diurnal observation of burrows
C2	Torre di Manfria	37.098339	14.140756	August 2013	Video footage of individuals collected
C3	Contrada Cammarana di Scoglitti	36.881895	14.437845	September 2015	Video footage of individuals collected
C4	Contrada Camarina	36.867973	14.445656	August 2016	Diurnal observation of burrows
C5	Randello-Braccetto	36.837548	14.457764	September 2015	Individuals and burrows photographed
C6	Marina di Ragusa	36.782817	14.555402	November 2016	Diurnal observation of burrows
C7	Sampieri (West)	36.720727	14.743714	June 2009	Individuals and burrows photographed
C8	Sampieri (East)	36.721350	14.729923	June–August 2007	Individuals and burrows photographed
C9	Contrada Concerie di Pachino	36.666656	15.055767	October 2016	Diurnal observation of burrows
C10	Marzamemi	36.740088	15.116487	August 2016	Individuals and burrows photographed

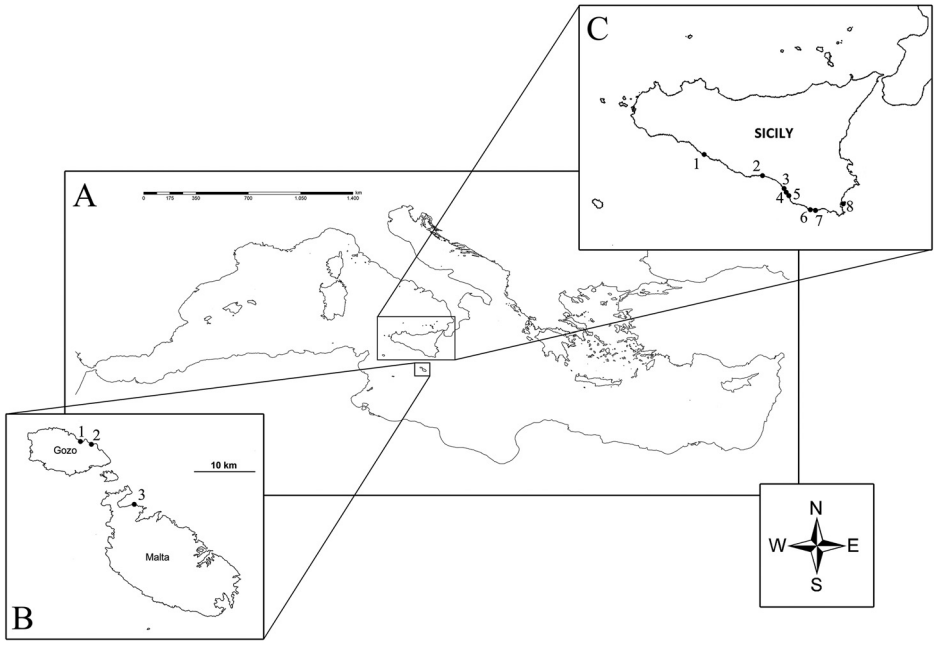

Figure 1. *Ocypode cursor* (Linnaeus, 1758) populations from the central Mediterranean Sea reported in the present paper (numbers correspond to the localities reported in Table I). (A) The Mediterranean Sea, with location of Maltese Islands and Sicily Island. (B) Magnification of the Maltese Islands. (C) Magnification of the Sicily Island.

farther west along the beach; (iii) sub-adult burrows were recorded as close as 1 m to each other, whilst adult burrows were more distant from each other; sub-adult individuals mostly excavated temporary burrows, whilst burrows excavated by adults were more permanent in nature; sub-adult and adult burrows had an average opening with of 1.5 cm and 3.5–4.0 cm, respectively. Temporary burrows have no well-defined opening and are excavated very close to the surface, lacking a central chamber, and only rarely have more than a single opening. Permanent burrows have a more uniform structure, with a well-defined opening leading to a good-sized central chamber, and normally have multiple openings. In addition, the sand surface around permanent burrows is normally punctuated by multiple crab footmarks leading into the same burrows from all directions (Figure 2(D)); (iv) when threatened, the crabs retreated seaward, even entering the sea, rather than to their burrows, in extreme circumstances; (v) two different types of burrows were observed on the beach: perfectly vertical burrows, mainly excavated by juveniles, and burrows with three different openings and excavated at an angle such that it assumed a slanted conformation,

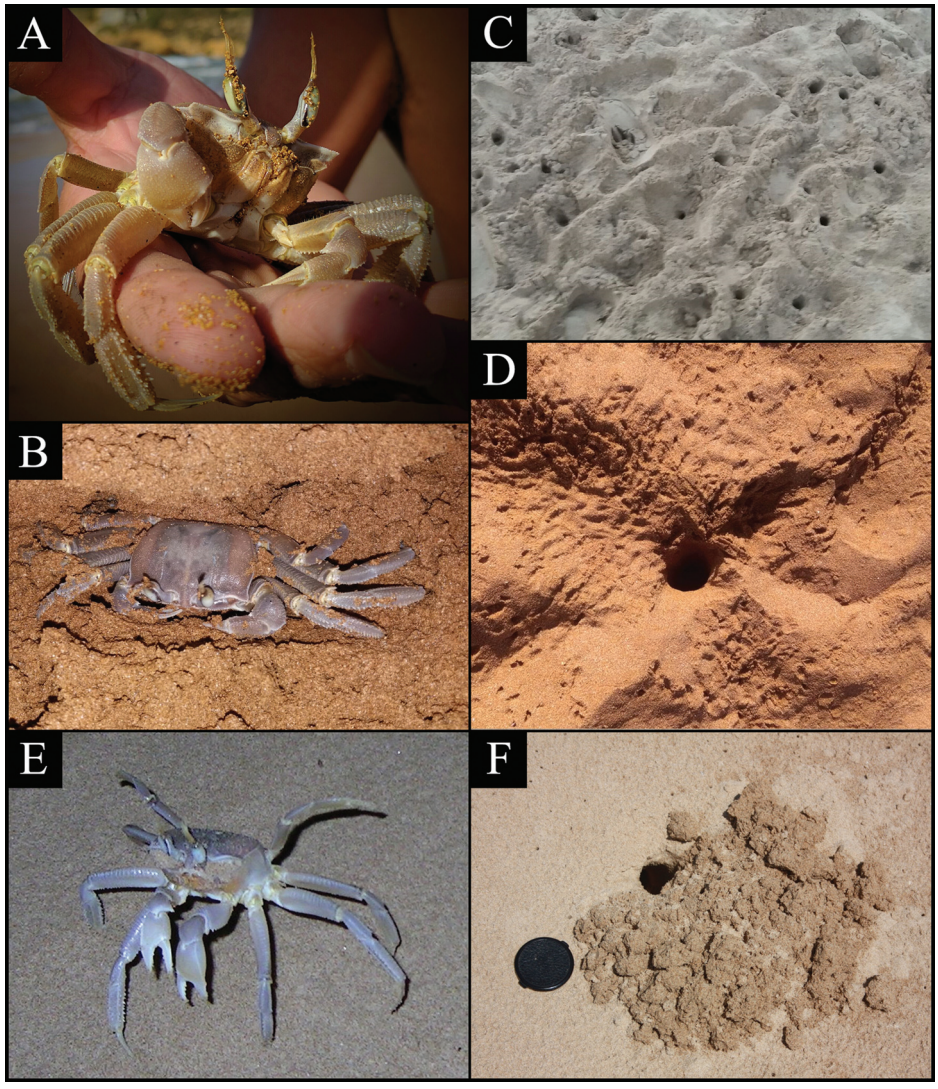

Figure 2. *Ocypode cursor* (Linnaeus, 1758) from the central Mediterranean Sea (Malta and Italy). (A) Photo of the tufted ghost crab sighted at Ramla l-Hamra (Malta) on 19 June 2016, and circulated on social media. (B) Adult ghost crab individual photographed at Ramla l-Hamra (Malta). (C) High density of burrows along the western half of the beach at Ramla l-Hamra (Malta). (D) Burrow at Ramla l-Hamra, with a convergence of different tracks. (E) Adult individual photographed at Sampieri (East) (Italy) in summer 2016. (F) Burrow photographed on the beach of Funcitella-Siculiana (Italy) in summer 2007.

having a maximum width of 4 cm and a maximum depth of 23 cm, mainly excavated by adults; (vi) ant lion adults and larvae, as well as the seagrass *Posidonia oceanica* (Linnaeus) Delile, were regularly observed at the bottom of the burrows. More rarely, partially consumed individuals of the isopod *Tylos europaeus* Arcangeli, 1938 were found, whilst on one occasion a specimen of *Pelagia noctiluca* (Forsskål, 1775) was also observed; (vii) the closest to the sea that burrows were excavated by *O. cursor* was 5 m; (viii) the tracks on the sand left by the passage of the tufted ghost crabs converged to a certain degree into common tracks.

During the first visit to Ramla l-Hamra, seven *O. cursor* individuals were observed, of which two were caught, measured and released. On the second visit to the same beach, 36 individuals were observed, of which 16 were caught, measured and released. Only 12 burrows were recorded during both the first and the second visit to the beach at San Blas, and four crab individuals were caught, measured and released from this sampling site. Finally, three *O. cursor* individuals were observed during the visit to Mgiebah, which took place during the day. Morphometric attributes measured on the Ramla l-Hamra and San Blas individuals are summarised in Table II.

Table II. *Ocypode cursor* (Linnaeus, 1758) morphometric attributes (in mm) measured on the Ramla l-Hamra and San Blas (Malta) individuals sampled (specimens ordered by increasing size). Abbreviations used: LC – carapace length; WC – carapace width; TS – total span.

No.	LC	WC	TS
Ramla l-Hamra			
1	6	7	48
2	9	10	74
3	10	11	80
4	10	12	80
5	11	12	81
6	20	30	159
7	26	33	167
8	30	41	174
9	31	41	182
10	32	41	101
11	32	38	181
12	33	43	187
13	36	43	184
14	36	43	185
15	36	43	185
16	40	50	205
17	40	50	210
18	46	53	230
San Blas			
1	17	19	80
2	31	32	130
3	44	46	140
4	49	50	120

The presence of *O. cursor* along the southern coasts of Sicily seems to be wide but scattered, ranging from Funcitella–Siculiana to Marzamemi (Figure 2(E–F)). This may suggest that the species has been present in the area for decades, but has presumably gone partially undetected. The oldest observations we received date back to summer 2007, when individuals and burrows were photographed in Sampieri (East) (Figure 2(F)). This is in agreement with the presence of a crab individual exhibited at the Natural History Museum of the Sicilian town of Comiso (MSNC 4532) (morphometric measurements: LC = 36 mm; WC = 44 mm; TS = 19 mm), which was sampled during summer 2007 in Sampieri (East).

There are no clear guidelines in the literature regarding how to distinguish between juvenile and adult stages of *O. cursor*. Strachan et al. (1999) hint that the cut-off point between the two life-cycle stages could be a carapace length (LC) value of 25 mm. Adopting such a proxy for our data, 66.6% and 75.0% of all measured individuals at Ramla l-Hamra and at San Blas, respectively, would be recorded as juveniles (Figure 3). Such proportions are in line with observations made on the Cypriot beach, with juvenile stages appearing mainly in early summer (our observations were made in July), with the fraction of adults increasing with the passage of the summer months.

Discussion

The *O. cursor* population at Ramla l-Hamra assessed in the current study exhibited some remarkable similarities within its Cypriot counterpart studied on the beach of Alagadi along the northern shore of Cyprus (see Strachan et al. 1999). These similarities included the fact that burrow depth increased with distance from the shore, with the crabs maintaining a constant height above the water table. This phenomenon has been documented for a number of sandy beach species (psammophiles), including the isopod *T. europaeus*, and is known as dynamic zonation (Defeo & McLachlan 2005). In the Cypriot study, burrows were recorded at a maximum distance of 7.0 m from the waterline, whilst the corresponding distance in the current study was 5.0 m. On non-microtidal beaches, such as those in the Atlantic (e.g. Cabo Verde archipelago), crabs venture farther inshore (up to 20 m away from the waterline), due to tidal excursions on the beach (Rodrigues et al. 2016).

The sediment particle diameter values ranged from 1.40 to 2.18 phi for the Cypriot beach, with the corresponding values for Ramla l-Hamra ranging from 1.69 to 2.70 phi, still equivalent to the medium sand category according to the Wentworth Scale (Deidun & Schembri 2008). Similar zonation patterns were observed for different crab age groups – in general, for both populations studied, juvenile crabs were zoned closer to the waterline than adults were. Whilst burrow width values for the two populations were similar (maximum values of 40 mm and 45 mm for the Maltese and Cypriot populations respectively), the near-vertical height of burrows was considerably higher (maximum height of 780 mm compared with 230 mm) for the Cypriot population. This might speculatively be attributed to a lower water table on the Cypriot beach, possibly due to the greater distance from the waterline, to the slightly coarser sediment sizes (which are normally associated with higher rates of water percolation) and/or to the higher air and sub-surface temperatures recorded on the Cypriot beach.

In terms of burrow density, the beach at Ramla l-Hamra covers an estimated surface area of 24,000 m^2, such that the observed numbers of burrows translate into burrow densities ranging from 0.005 to 0.007/m^2 for the beach. These values are considerably lower than was reported by Strachan et al. (1999) for the northern Cypriot beach, possibly hinting at the vulnerability of the

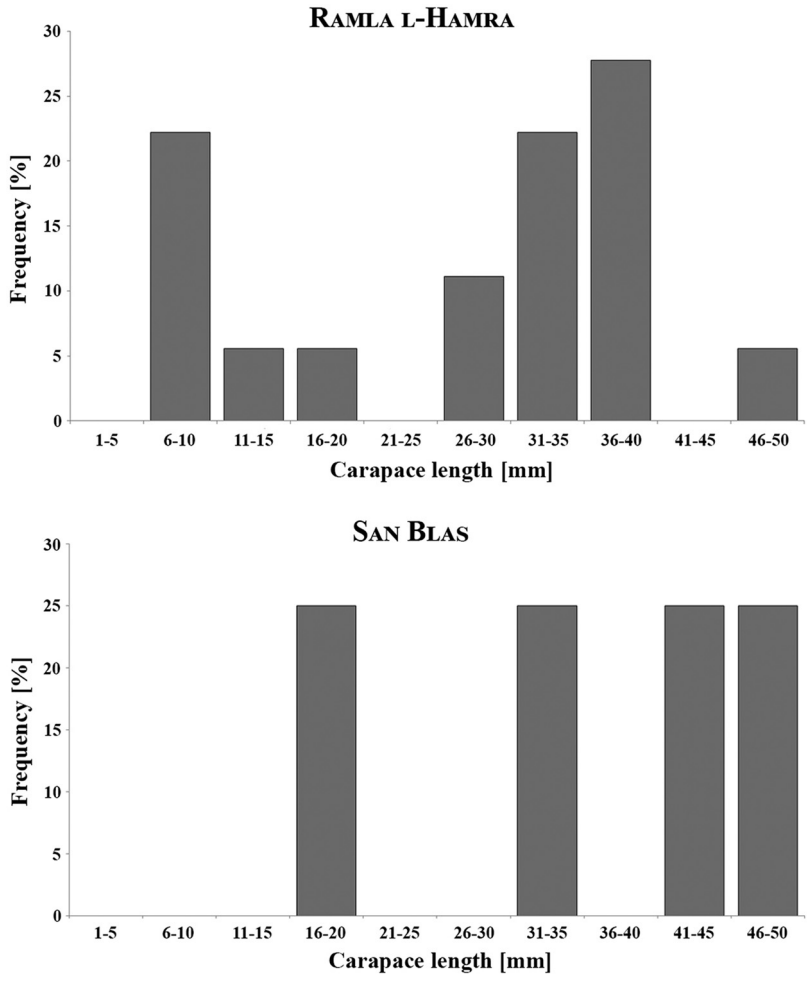

Figure 3. Histogram of the length [mm] – frequency [%] distribution of *Ocypode cursor* (Linnaeus, 1758) specimens collected: Ramla l-Hamra – N = 27; San Blas – N = 4.

Maltese populations for the species. Given the patchy, non-uniform and clustered distribution of the *O. cursor* burrows at Ramla l-Hamra, burrow density is not a good proxy for estimating individual density on the same beach. The burrows were in fact arranged within two major clusters, one located at the mouth of the watercourse opening up to the beach and the other burrow cluster located 40 m to the west, at the foot of the dune scarp. A number of individual burrows, which were largely abandoned, were recorded within the inter-cluster beach interval. The actual location of the burrow clusters might be an indicator of the suitability of different areas on the same beach to support ghost crab populations. In view of the lack of natural predators of the ghost crab at Ramla l-Hamra and the relatively uniform distribution of bathers on the same beach, heterogeneity in the sand interstitial environment, rather than predation pressure or human disturbance, is probably the main driver behind the observed clustered distribution of ghost crab burrows a Ramla l-Hamra.

From the carapace width values given in Strachan et al. (1999) for the ghost cab individuals sampled on the northern Cyprus beach, similarities to the Maltese populations emerge. In fact, the majority of carapace width values within the Cypriot and Maltese populations fall within a range of 25–45 mm, although the highest carapace width value recorded on the northern Cyprus beach (59 mm) was higher than the corresponding value recorded on Maltese beaches (53 mm). Similarly, in terms of carapace length, most of the individuals sampled on the Cypriot and Maltese beaches lay within the 20–40 mm range, with the highest value recorded in northern Cyprus (53 mm) being higher than the corresponding one from the Maltese beaches (49 mm).

The report from Mgiebah beach is somewhat surprising, as this site is separated from the other two beaches where the crab has been recorded (i.e.

Ramla l-Hamra and San Blas) by a number of other larger sandy beaches which could potentially host (by virtue of their sand granulometry and aspect) the crab (e.g. Mellieha Bay, Armier, White Tower Bay), but from which the species has not been recorded so far. Such a disparate distribution of *O. cursor* along the sandy coastline of the Maltese Islands could putatively be explained in terms of beach human occupancy differences (the beaches where the crab is absent are especially popular during the summer season) or in terms of granulometric differences, with the un-colonised beaches being potentially characterised by sediment particle sizes which do not support the establishment of ghost crab populations (sediment grain size is of great importance for beach burrowing species as it determines factors such as sand penetrability, and interstitial moisture and organic matter content).

One can only speculate about the dispersal mechanism originally bringing the species to the Maltese Islands and responsible for inter-beach dispersal on the islands. The fact that it is much more widespread on Sicily and the fact that all three colonised Maltese beaches have a north or north-eastern aspect, directly facing the island of Sicily, might suggest a secondary colonisation of the Maltese beaches, putatively through rafting on floating debris (e.g. seagrass litter, wood) or presumably through phoresy on sea turtles, especially since the species does not use advection in water as a means to disperse its larvae.

In the Maltese Islands, LN (Legal Notice) 311 of 2006 makes *O. cursor* a protected species in the Maltese Islands, going a step further than the Habitats Directive, which the legislation seeks to transpose. Most probably, this was done as a precautionary measure, especially since the species was only previously recorded from the Maltese Islands through the sighting of a single individual at Ramla l-Hamra, which was never photographed or caught, in the early 1990s (Mallia et al. 2002). Such a record has never been published in the scientific literature. This suggests that the species might have maintained a low profile on the beach through low individual abundances, such that it went largely undetected. To this it should be also added that shore decapods largely suffer from a lack of studies, as recently suggested by Crocetta et al. (2011) while recording two *Pachygrapsus* Randall, 1840 species in the same area. Nevertheless, the confirmed occurrence of the species in such high densities on at least three Maltese beaches puts the onus now on the Maltese environmental authorities to adopt conservation measures to safeguard the protected status of the species, given the popularity of Maltese beaches during the bathing season.

Interestingly, almost all Sicilian beaches where ghost crabs were sighted are frequented by sea turtles as a nesting place (Mingozzi et al. 2007; Casale et al. 2012; Garofalo et al. 2016). In many countries, the increase in ghost crab abundance is frequently associated with an active predation on hatchling turtles (Barton 2005). It might be worth investigating in future whether, and if so, how, the two phenomena – turtle nesting and ghost crab occurrence – are related to each other.

Acknowledgements

Noel Attard and Marika Grech first alerted us about the sighting of *O. cursor* at Ramla l-Hamra. Esther Sciberras offered valuable assistance in the field. Alessandro Cavallo, Davide Campo, Filippo Spadola and Davide Ciravolo contributed with sightings from several Sicilian beaches. Carlo Froglia provided data on the published record from Lampedusa. Mr. Darrin Stevens, Unit Manager at the Environment and Resources Authority (ERA) of Malta, provided useful insight on the conservation legislation through which the species is protected. We are grateful to all of them.

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